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Research Article

Prioritize Strategies to Address the Sustainable Supply Chain Innovation Using Multicriteria Decision-Making Methods

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Today, due to the increase in people's awareness of environmental issues and the strict policies of governments, the competitiveness of companies depends on considering environmental issues at all levels of the supply chain. However, the implementation of green supply chain management strategies has lots of different risks. The main contribution of this research is to evaluate and rank the companies in the tire industry with an emphasis on the environmental risks of the sustainable supply chain using the hybrid best-worst method (BWM) and fuzzy VIKOR (FVIKOR). First, data analysis was implemented by applying the BWM technique, which has higher reliability than other similar techniques. Next, the importance of the indicators involved in the risk of the green supply chain, including operational, supply, product return, financial, demand, organizational, and government, was calculated. Finally, according to the calculated weights for each criterion, five active companies in the tire industry were ranked using the FVIKOR technique. The results of prioritizing criteria and subcriteria showed that "financial risks" are the most important indicator among the indicators involved in green supply chain risk. Among the subcriteria, "rates related to inflation and currency" from the cluster of financial risks were recognized as the most important subcriteria. Moreover, the results of the ranking of five companies in the tire industry indicated that Dana Company is in the best situation in terms of green supply chain risks. Finally, a series of practical suggestions for managers and a series of scientific suggestions for future research have been presented.

1. Introduction

Controlling and reducing pollution in order to protect the environment and prevent global warming is one of the most critical issues and concerns of countries in the world [1]. Traditional supply chains did not pay enough attention to environmental issues. However, with the increase in awareness of environmental issues, risks were brought to the industries polluting the environment, and as a result, risk management seemed necessary in such a situation [2]. The existence of these problems led supply chain management to a new concept called green supply chain management (GSCM), which focuses on simultaneous attention to the organization and the environment [3]. Due to the type of input materials, process steps, and output products, the tire industry is considered one of the high-risk industries in terms of the production of environmental pollutants.

Therefore, organizations and institutions must pay attention to environmental issues throughout their supply chain in order to improve their competitive advantage as well as improve environmental issues in order to achieve sustainable development. It can be achieved through the implementation of a green approach in the supply chain. The green supply chain creates two-way benefits for the environment and the organization by considering environmental issues in addition to economic benefits [4]. Despite the importance of green supply chain management, one of the main problems that stand in the way of its success is the supply chain risk issue. The risks associated with the green supply chain and the sources of occurrence of these risks cause the deviation of the green supply chain management from its original path and reduce the possibility of organizations paying attention to environmental and economic performance [5].

Despite much research in the field of the green supply chain, so far, no comprehensive research has been performed regarding risk analysis in the green supply chain in the rubber industry. In addition, the need to deal with the risk of the green supply chain and its resources can be examined from the three perspectives of the organization and the constitution, which are briefly discussed as follows:

(1) The need to consider environmental issues along with economic benefits [6–10]

(2) The need to improve environmental issues to achieve sustainable development and improve competitive advantage [11–14]

(3) The need to save energy resources, reduce pollutants, eliminate or reduce waste, create value for customers, and finally increase productivity [15]

(4) Donating to a developed country with a clean environment for future generations

Considering different aspects of GSCM, the contribution of this research can be summarized as follows:

(i) Identifying the most important strategies and criteria to address the sustainable supply chain

(ii) Implementing BWM to rank the factors affecting the sustainability of the tire industry

(iii) Implementing FVIKOR to rank the companies related to the tire supply chain

The data required in the present study were collected in three stages. First, with a detailed and extensive review of the literature, the criteria involved in the risk of the green supply chain were extracted. Next, to adopt and specialize the extracted criteria, a survey was conducted from at least ten experts in the studied industry by applying the snowball sampling method. Finally, using the final weights obtained from the BWM technique, it was decided to rank the criteria involved in the risk of the green supply chain in the tire industry.

In the following section, a review of the literature on the green supply chain has been discussed. In Section 3, the research methodology is presented. In Section 4, data analysis was provided by using BWM and FVIKOR techniques. Section 5 is provided to discuss the numerical results. Finally, the conclusion and suggestions for future research are expressed in Section 6.

2. Literature Review

In this section, different aspects of sustainable supply chains are presented. First, green supply chain management will be defined. Next, risk management in green supply chains will be discussed. Finally, a comprehensive analysis of the literature will be provided.

2.1. Green Supply Chain Management (GSCM). The main source of green supply chains comes from the idea of supply chain management and sustainable development theory. The literature related to green supply chain management has not been able to use a comprehensive and inclusive definition for this concept [16]. In this regard, Wang et al. [17] consider the green supply chain to include the processes of raw material supply, production, logistics management, distribution and services, use, and recycling, which due to the ring structure and the closed-loop supply chain management, coordination, and controlling the chain and material flows, the models presented for this chain are very complex. Zhu et al. [18] stated that the field of green supply chain management depends on the researcher's goal and how to reach the problem [18]. According to Kaur et al. [19], green supply chain management includes all organizational processes, product design, sourcing, production, and distribution to product recycling [19].

2.2. Risk Management and Green Supply Chain. From a managerial point of view, the risk is what may harm or even stop normal and planned activities [20]. Trade and business make sense due to the existence of risk and uncertainties. Because if there is no risk in something, it will not have economic value because added value will not be created. Uncertainties and uncertainty are considered at two tactical levels (short-term and long-term) [21]. In relation to short-term uncertainty, we can mention things such as the demand for a product or a set of products. At the same time, long-term uncertainty includes things such as market expansion or product line development. Risks related to the tactical level (short-term) are very different from long-term plans.

The risk of the tactical level and the costs imposed due to its consequences can be calculated and predicted. It should be noted that the risk at the level of long-term planning is much more and has different forms from different perspectives. On the other hand, supply chain management is responsible for all transfers and transformations of resources [22].

On the other hand, green supply chain management deals with environmental issues in supply chain management. Specifically, green supply chain risk is any incident or an unpredictable event affecting the flow of environmentally friendly materials and green products from the start to the end, which is the final consumer. Among the risks related to the green supply chain, risks related to suppliers, customers, and technology have a significant effect on the performance of the supply chain [23–25]. The mentioned risks may have severe and widespread consequences, including delays in the delivery of goods or even nondelivery of goods, creating financial disturbances and irregularities, returning damaged and inferior products, and many other losses; this pointed out that each of them can be the beginning of subsequent more serious losses. Therefore, it is very important to identify, understand, and manage risks in the green supply chain in order to achieve the desired goals [31].

2.3. Literature Analysis. In recent years, many studies in the GSCM risk field have considered a specific area of the GSCM and the risks associated with that area. For example, Hu et al. [27] adopted a quantitative approach to analyze the risks related to green parts according to the European Union standards. Danley et al. [31] presented a model to investigate the risks related to green supply chain production operations. Roman et al. [29] presented a model to identify and evaluate risks in an effective green supply chain. Wang et al. [30] proposed a model to identify the risks caused by the implementation of green projects in the fashion industry. Other researchers also weighted and ranked green supply chain risk criteria in different industries using multicriteria decision-making techniques, including AHP and fuzzy AHP [31–33]. In order to achieve an efficient GSCM and control the risks, various organizations consider other factors. These factors include supply and demand risks, production process risks, knowledge and technology transfer risks, legal risks, financial risks, and environmental risks [5, 24, 34, 35]. Lintukangas et al. [36] investigated the effect of direct risk management, risks related to product quality and price, and indirect risks (risks related to tax laws and brand image) of green supply chain management. Akbarzadeh et al. [37] evaluated the risks of a sustainable and resilient supply chain. For this purpose, using the fuzzy C-mains technique, they clustered suppliers based on three components, namely, economic, social, and environmental components.

Recently, Goli and Mohammadi [38] proposed a hybrid MCDM method to evaluate the performance of supply chains. Haiyun et al. [39] proposed a hybrid method based on quality function deployment and multiobjective optimization by ratio analysis to extract the innovation strategies of green supply chain management. Li et al. [40] proposed a Stackelberg game model to find a suitable price strategy for green supply chains. They revealed that the pricing strategy has an evident impact on the profit level of supply chain members. Liu and Zhang [41] assessed the dual-channel supply chain and proposed several cost-sharing models. In these models, the pricing strategy is evaluated.

In order to conduct this research, the main criteria of GSCM risks are derived from the literature. The summary of the reviewed literature is presented in Table 1. It should be noted that the six dimensions of green supply chain risk used in the present study, along with 24 indicators, are presented in Table 1.

After reviewing the related papers, the research gap in this field can be summarized as considering different aspects of GSCM and finding the suitable strategy for GSCM using hybrid fuzzy MCDM methods. This research gap is addressed in this research, and hybrid BWM-FVIKOR is implemented to address the sustainable and green supply chain innovation.

3. Methodology

The current research is based on the practical purpose and collecting descriptive survey information. Thematically, it is placed in the field of green supply chain management and specifically in the field of risk analysis in the green supply chain. The scope of the study is the companies active in the rubber industry that considered the minimum requirements of the green supply chain. The statistical population of the current research is the high-level managers of 5 companies active in the rubber industry who have a relative understanding of the concepts and topic of the research. In order to rank the factors involved in the risk of GSC from the point of view of five experts in the tire industry, pairwise comparisons were used. It should be noted that in multicriteria decision-making methods, there is no relationship with a specific formula for determining the sample size, but due to the smallness of the target population, an attempt is made to enumerate experts. Moreover, rate adjustment was used, and after revising and recompleting some incompatible matrices, the compatibility of all comparisons was finally confirmed. In the following section, BWM and FVIKOR techniques have been presented in detail.

3.1. Best-Worst Method (BWM). The best-worst method is presented first by Rezaei [39]. This method is a developed version of AHP with an optimization approach [39]. The initial model presented for the BWM technique was a nonlinear model that may lead to optimal solutions. The linear model of this technique was presented by Rezaei [39], which leads to the global-optimal solution. In this method, the most important ($A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})$) and least important criteria ($A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})$) optimal solutionsd is descirbled aeee are defined. Then, it minimizes a mathematical model to find the optimal weight of criteria ($(W_1^*, W_2^*, \ldots, W_n^*)$) considering the nonnegativity of the weight of each activity. The model is presented as follows:

Table 1: Summary of the reviewed literature.

Dimension	Criteria	Explanation	Reference
Operational risks	Failure of machinery and equipment	Any breakdown of machinery and equipment causes interruptions and negatively impacts the effectiveness of GSC.	Yang and Li [24]
	Design risks	This index includes mistakes in the design of the green process methodology, such as green materials, operations, and methods.	Yang and Li [24]; Ma et al. [31]
	Lack of skilled workers	This index includes the lack of understanding and knowledge of green methods and activities among workers, which affects the organization's green supply chain performance.	Yang and Li [24]; Ma et al. [31]
	The level of green technology	This index actually explains managers' high knowledge and understanding of the applicability of new green technologies in business.	Mangla et al. [5]
Supply risks	Purchase cost risks	Purchase risks include green and environmentally friendly materials that cause costs to the final supplier. It may affect environmental performance.	Yang and Li, [24]; Qian Lei, [35]
	Loss of key suppliers	Failures affecting key suppliers that may affect GSC's performance.	Yang and Li, [24]; Qian Lei, [35]
	Supplier quality issues	It includes issues that may affect the quality performance of the supplier's GSC from an industrial perspective.	Tang and Li, [42] Ma et al., [31]; Mangla et al., [5]
	Environmentally friendly raw materials	Industries are usually faced with failures and breakdowns of environmentally friendly raw materials.	Mangla et al. [5]
Product return risks	Reverse logistics planner risks	Risks related to logistics network design can affect the effective adoption of GSC activities in business.	Mangla et al. [5]
	Risks related to product returns from customers	The risks of the obligation to return the product for recycling affect the collection procedure and also affect the mechanism of product recycling in GSC.	Mangla et al. [5]
	Risks related to capacity and inventory redesign	Inventory and capacity design risks in recycling centers can affect the complexity of the green recycling system.	Mangla et al. [5]
Financial risks	Risks related to limitations in financial resources	Any issue related to financing can definitely affect GSC's business goals.	Tang and Li [42] Ma et al. [31]; Mangla et al. [5]
	Risks related to inflation and currency changes	Inflation and changes in prevailing exchange rates may affect the financial concerns and, thus, the effectiveness of the GSC.	Yang and Li [24]
	Risks related to poor financial plans	The inability and lack of financial plans and controls may affect GSC's performance.	Mangla et al. [5]
Demand risks	The whiplash effect caused by false information about the demand	Information deviation of green demand in GSC is known as the leather whip effect. This issue for the organizational green supply chain will cause problems in demand for green products and, as a result, reduce green performance.	Yang and Li [24]; Qian Lei [35]
	Market dynamics	Market dynamics are the result of limited resources and common preferences of individuals and have a significant impact on green product demand and green supply chain efficiency.	Mangla et al. [5]; ma et al. [31]
	Loss of key customers	Losing key customers can significantly impact the adoption and effective implementation of green supply chain management.	Yang and Li [24]; Qian Lei [35]
	Competitive risks	Industries are at significant risk due to huge competition in the market. Competitors' approaches and strategies related to the green issue can affect the uncertainties of green product demand from an industrial point of view.	Mangla et al. [5]

Table 1: Continued.

Dimension	Criteria	Explanation	Reference
Organizational and government risks	Failure of management lines	This risk indicates management risks in the failure of management policies in adopting GSC methods.	Mangla et al. [5]
	Risks caused by government policies	Inefficiency or weakness of government laws and policies in terms of environmental protection definitely affects the adoption of GSC from an industrial point of view.	Mangla et al. [5]
	The risk of information asymmetry across the green supply chain	Deviation and disorganization in information flow among GSC members can affect the effectiveness of green supply chain management.	Mangla et al. [5]
	Lack of strategic goals in the organization	It is difficult to successfully implement green supply chain activities without considering the strategic perspective of green supply chain management.	Mangla et al. [5]
	Legal risks	Legal risk is caused by the uncertainty of clauses of laws and contracts or ambiguity in the application or interpretation of contracts, laws, or regulations in the implementation of green supply chain management.	Mangla et al. [5]
	Partnership risks	Disagreements between colleagues and partners lead to GSC dysfunction.	Mangla et al. [5]

$$\begin{aligned}
&\mathrm{Min}\,\xi^L,\\
&s.t,\\
&\left|w_B - a_{Bj}w_j\right| \le \xi^L, \text{for all } j,\\
&\left|w_j - a_{jw}w_w\right| \le \xi^L, \text{for all } j,\\
&\sum_{j=1}^{n} w_j = 1,\\
&w_j \ge 0, \text{for all } j.
\end{aligned} \tag{1}$$

In order to find the best weight for each criterion, the proposed model should be optimized using GAMS software [40, 41].

3.1.1. Calculation of the Inconsistency Rate (IR). In order to calculate the incompatibility rate, the ξ^* value was obtained in the previous step and the reported compatibility index (CI) for different values of a_{BW}. Table 2 presents the CI according to the following equation:

$$\mathrm{IR} = \frac{\xi^*}{CI}. \tag{2}$$

3.2. FVIKOR Technique. After determining the weight of the subcriteria, it is time to rank the options using the FVIKOR method. In the following steps, the method of ranking options using the FVIKOR method is explained step by step in.

Step 1. Formation of fuzzy decision matrix

The fuzzy decision matrix is formed based on experts' opinions and using verbal expressions and equivalent fuzzy numbers. Verbal expressions and equivalent fuzzy numbers used in the present research are presented in Table 3.

Table 2: Compatibility index specific to the BWM technique.

$\mathbf{a_{BW}}$	1	2	3	4	5	6	7	8	9
CI	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

Table 3: Verbal expressions and definite and fuzzy equivalents.

Verbal expression	Definitive equivalent	Fuzzy equivalent
Very low	1	(0,0,1)
Low	2	(0,1,3)
Almost low	3	(1,3,5)
Medium	4	(3,5,7)
Almost high	5	(5,7,9)
High	6	(7,9,10)
Very high	7	(9,10,10)

Step 2. Unscaling the decision matrix

In this step, we scale the fuzzy decision matrix based on the following steps and relationships.

Step 2.1. Determine the best and worst value for each criterion

The best and worst values for each criterion are identified and named as $\tilde{f}_i^*$ and $\tilde{f}_i^0$, respectively.

If the j-th criterion represents profit, then $\tilde{f}_i^*$ and $\tilde{f}_i^0$ are obtained from the following equations:

$$\tilde{f}_i^* = \max_i \tilde{f}_{ij}, \quad i = 1, 2, \ldots, n \text{ for } j \in j^b, \tag{3}$$

$$\tilde{f}_i^0 = \min_i \tilde{f}_{ij}, \quad i = 1, 2, \ldots, n \text{ for } j \in j^b. \tag{4}$$

If the j-th criterion represents cost, then $\tilde{f}_i^*$ and $\tilde{f}_i^0$ are obtained from the following equations:

$$\tilde{f}_j^* = \min_i \tilde{f}_{ij}, \quad i = 1, 2, \ldots, n \text{ for } j \in j^c, \tag{5}$$

$$\tilde{f}_j^0 = \max_i \tilde{f}_{ij}, \quad i = 1, 2, \ldots, n \text{ for } j \in j^c. \tag{6}$$

Step 2.2. Determination of normalized values

After determining the best and worst value of each criteria as $\tilde{f}_j^* = (1_j^*, m_j^*, u_j^*)$, $\tilde{f}_j^0 = (1_j^0, m_j^0, u_j^0)$, the fuzzy normalized values are obtained using the following equations:

$$\tilde{d}_{ij} = \frac{\tilde{f}_j^* \ominus \tilde{f}_{ij}}{u_j^* - l_j^0} \text{ for } j \in j^b, \tag{7}$$

$$\tilde{d}_{ij} = \frac{\tilde{f}_{ij} \ominus \tilde{f}_j^*}{u_j^0 - l_j^*} \text{ for } j \in j^b. \tag{8}$$

Step 3. Determining the value of utility $(\tilde{S}_i)$ and regret of each option $(\tilde{R}_i)$

The utility value $(\tilde{S}_i)$ expresses the relative distance of the i-th option from the ideal point, and the regret value $(\tilde{R}_i)$ expresses the maximum discomfort of the i-th option from the ideal point which is calculated. If $\tilde{R}_i = (R_i^1, R_i^m, R_i^u)and\tilde{S}_i = (S_i^1, S_i^m, S_i^u)$, then we can use the following equations:

$$\tilde{S}_i = \sum_{j=1}^{J} \left(\tilde{w}_j \widetilde{d_{ij}}\right), \tag{9}$$

$$\tilde{R}_i = \text{Max}\left\{\left(\tilde{w}_j \widetilde{d_{ij}}\right)\right\}. \tag{10}$$

Step 4. Calculation of VIKOR index $(\tilde{Q}_i)$

In this step, the action of the VIKOR index $(\tilde{Q}_i)$ is calculated for each of the options using equations (11)–(15). The V parameter takes values between zero and one based on the opinion of experts. If $\tilde{Q}_i = (Q_i^1, Q_i^m, Q_i^u)$, then we can use the following equations:

$$\tilde{Q}_i = v \frac{\left(\tilde{S}_i \ominus \tilde{S}^*\right)}{S^{0u} - S^{*l}} (1 - v) \frac{\left(\tilde{R}_i \ominus \widetilde{R^*}\right)}{S^{0u} - S^{*l}}, \tag{11}$$

$$\tilde{S}^* = \min_i \tilde{S}_i, \tag{12}$$

$$\tilde{S}^{0u} = \max_i S_i^u, \tag{13}$$

$$\mathrm{R}^* = \min_i \tilde{R}_i, \tag{14}$$

$$\tilde{R}^{0u} = \max_i R_i^u, \tag{15}$$

where parameter V is a weight for the maximum group favorability, whose value can be between 0 and 1, which is considered 0.5 based on the opinion of experts in this research. In the present study, the relationship was used to determine the fuzzy values of Q, R, and S. If $\tilde{N} = (1, m, u)$ is a triangular fuzzy number. Then, we can calculate the crisp value using the following equation:

$$\text{Crisp}(\tilde{N}) = \frac{1 + 2m + u}{4}. \tag{16}$$

Step 5. Ranking options based on Q, R, and S values

In this step, the options are ranked into three groups based on Q, R, and S values.

Step 6. Determining the final answer and final ranking of options

In this case, to make a decision, two conditions are checked, and based on these two conditions, there are three situations in which the final decision is made.

First condition: acceptable advantage condition.

If $A^{(1)}$, $A^{(2)}$, and $A^{(3)}$ are the first, second, and worst options based on the value of Q, and n is equal to the number of options; the following equation should be satisfied:

$$\frac{\left[Q\left(A^{(2)}\right) - Q\left(A^{(1)}\right)\right]}{\left[Q\left(A^{(1)}\right) - Q\left(A^{(1)}\right)\right]} \geq \frac{1}{n - 1}. \tag{17}$$

The second condition: the condition of acceptable stability in decision-making.

Alternative A^1 must be recognized as the top rank in at least one of S or R groups. The states that may occur based on these two conditions are

The first mode: when the first condition is not fulfilled, a set of alternatives (including M alternatives) are selected as the best alternatives. The maximum value of M is calculated using the following equation:

$$Q(A(2)) - Q(A(1)) < \frac{1}{n - 1}. \tag{18}$$

The second mode: when the first condition is met but the second condition is not met, options A^1 and A^2 are selected as the best options.

The third mode: if both conditions are met, the ranking will be based on Q. (decreasingly: the lower the Q, the better the option).

4. Numerical Results

As mentioned earlier, in the current research, two techniques, BWM and FVIKOR, have been used to analyze the data. In the following section, the implementation of these techniques has been discussed step by step.

$$\begin{aligned}
&\min \xi^L,\\
&s.t,\\
&|w_4 - 5w_1| \le \xi^L,\\
&|w_4 - 9w_3| \le \xi^L,\\
&|w_4 - 54| \le \xi^L,\\
&|w_4 - 2w_6| \le \xi^L,\\
&|w_1 - 2w_3| \le \xi^L,\\
&|w_2 - 2w_3| \le \xi^L,\\
&|w_5 - 2w_3| \le \xi^L,\\
&|w_4 - 4w_3| \le \xi^L,\\
&W_1 + W_2 + W_3 + W_4 + W_5 + W_6 = 1,\\
&W_1, W_2, W_3, W_4, W_5, W_6 \ge 0.
\end{aligned} \tag{19}$$

4.1. Weighting Criteria Using the BWM Technique

Step 1. Determining a set of decision criteria, which is presented in Table 1.

Step 2. Determining the best, most important, most desirable, and worst criteria. The most important and least important criteria have been selected as follows: the most important criterion is financial risks, and the least important criterion is product recycling risks.

Step 3. Determining the degree of preference of the best and most important criterion over other criteria using numbers 1 to 9. The results of this comparison by expert 1 will be in Table 4. As can be seen in Table 4, the preference of the most important criterion (financial risks) compared to the first criterion (operational risks) is five times ($aB1 = 5$), compared to the second criterion (supply risks) five times ($dB2 = 5$). The ratio compared to the third criterion of product recycling risks, which is the least important criterion, is nine times ($dB3 = 9$) and compared to the fifth (demand risks) and sixth (organizational and government risks) four times ($dB5 = 4$), respectively.

Step 4. Determining the degree of preference of other criteria compared to the worst and least important criteria using numbers 1 to 9. The results of this comparison will be shown in Table 5. As can be seen in Table 5, the preference for the first criterion over the least important criterion is 2 ($a1w = 2$), and the preference for the second criterion over the least important criterion is 2 ($a2w = 2$).

The preference for the fourth criterion (the most important criterion) compared to the least important criterion is 9 ($a4w = 9$), the preference for the fifth criterion compared to the least important criterion is 2 ($asw = 2$), and the preference for the sixth criterion compared to the least important criterion is 4 ($a6w = 6$).

Step 5. Determining the final weights of the criteria: as can be seen, the result of placing the numbers of paired comparisons (listed in Tables 4 and 5) in equation (1) will yield a nonlinear programming model, and solving this nonlinear programming model in addition to determining the final weights of the main criteria of the research will also give the value of ξ^*, which will be used to calculate the compatibility rate.

The optimal value of weights and the inconsistency rate is as follows:

$$\begin{aligned}
&W_1^* = 0.093, W_2^* = 0.093,\\
&W_3^* = 0.050, W_4^* = 0.448,\\
&W_5^* = 0.108, W_6^* = 0.208,\\
&\xi^* = 0.154,\\
&CR = \frac{\xi^*}{CI} = \frac{0.154}{5.23} = 0.0294 \le 0.1.
\end{aligned} \tag{20}$$

As seen, the method of calculating the weight of each of the main research criteria during the five steps of the BWM technique was explained based on the opinion of one of the experts. In the following paragraph, using the information obtained from the completed questionnaires, the weights of other criteria and subcriteria were calculated in the same way and through five steps by all five experts. Finally, to gather the opinions of the experts (six experts), the arithmetic mean of the weights was calculated. It is used for each criterion. It is worth noting that due to the high volume of calculations, details are omitted, and the final weights of the criteria and subcriteria are presented directly in Tables 6–12.

As can be seen, the inconsistency rate of all comparisons is less than 0.1 and close to zero, which confirms the appropriate consistency and the high reliability of the obtained results. In order to calculate the final weights of the composite criteria, it is sufficient to multiply the average weight of each criterion by the weight of the corresponding dimension. Table 13 shows the final weight and rank of each green supply chain risk criterion in the studied organization. As can be seen, the risks related to changes in the inflation rate and currency from the cluster of financial risks with a weight equal to 0.213789 are known as the most important criteria. Moreover, the measures of the whiplash effect caused by wrong information about the amount of demand and the loss of key customers from the cluster of demand risks have taken the second and third positions, respectively. The criterion of risks related to the redesign of capacity and inventory from the cluster of product return risks was recognized as the least important criterion from the point of view of experts in the rubber industry.

Table 4: Pairwise comparison of the most important criterion with other criteria.

Criteria	Operational	Supply	Recycle	Financial	Demand	Organizational and government
Risk (most important)	5	5	9	1	4	2

Table 5: Pairwise comparison of other criteria with the least important criterion.

Criteria/risks	Least important criterion/risk: recycling
Operational	2
Supply	2
Product recycling	1
Financial	9
Demand	2
Organizational and government	4

Table 6: The average weights of the main research dimensions.

Criterion	$W^*{}_j{}^M$	Weight
Operational risks	$W^*{}_1{}^M$	0.1166
Supply risks	$W^*{}_2{}^M$	0.1038
Product return risks	$W^*{}_3{}^M$	0.044
Financial risks	$W^*{}_4{}^M$	0.3062
Demand risks	$W^*{}_5{}^M$	0.2112
Organizational and government risks	$W^*{}_6{}^M$	0.2182
Inconsistency rate	0.029	Consistent

Table 7: Average weights of operational risk criteria.

Criterion	$W^*{}_j{}^M$	Weight
Failure of machinery and equipment	$W^*{}_1{}^O$	0.3466
Design risks	$W^*{}_2{}^O$	0.0588
Lack of skilled workers	$W^*{}_3{}^O$	0.1874
The level of green technology	$W^*{}_4{}^O$	0.4072
Inconsistency rate	0.015	Consistent

Table 8: Average weights of supply risk criteria.

Purchase cost risks	$W^*{}_j{}^S$	Weight
Loss of main supplier	$W^*{}_1{}^S$	0.115
Supplier quality issues	$W^*{}_2{}^S$	0.339
Environmentally friendly raw materials	$W^*{}_1{}^S$	0.113
Inconsistency rate	$W^*{}_4{}^S$	0.433
Purchase cost risks	0.029	Consistent

After determining the weight of the criteria, it is time to rank the companies active in the rubber industry. In the following section, this issue is discussed.

4.2. Ranking the Alternatives Using the FVIKOR Technique. After determining the final weight of the criteria involved in the green supply chain risk, it is time to rank the studied companies using the FVIKOR technique. The evaluation of options based on criteria according to fuzzy numbers, and verbal expressions listed in Table 13 is calculated. Table 14 shows the final results of ranking alternatives based on R, S, and Q indices.

As can be seen in Table 14, based on the results of the ranking of the studied companies using the FVIKOR technique, Dena was placed in the best position in terms of green supply chain risks, followed by Artville tire, Barez, and Kavir tire.

Table 9: Average weights of product return risk criteria.

Criterion	$W^*{}_j{}^{PR}$	Weight
Reverse logistics design risk	$W^*{}_1{}^{PR}$	0.4316
Product return risk	$W^*{}_2{}^{PR}$	0.49
Container redesign risk	$W^*{}_3{}^{PR}$	0.0784
Inconsistency rate	0.029	Consistent

Table 10: Average weights of financial risk criteria.

Criterion	$W^*{}_j{}^F$	Weight
Risk related to financial resources	$W^*{}_1{}^F$	0.2242
The risk of inflation and currency changes	$W^*{}_2{}^F$	0.6982
The risk of poor financial plans	$W^*{}_3{}^F$	0.0776
Inconsistency rate	0.014	Consistent

Table 11: Average weights of demand risk criteria.

Criterion	$W^*{}_j{}^D$	Weight
False whiplash effect on the amount of demand	$W^*{}_1{}^{GD}$	0.115
Market dynamics	$W^*{}_2{}^D$	0.339
Loss of key customers	$W^*{}_3{}^D$	0.113
Competitive risks	$W^*{}_4{}^D$	0.433
Inconsistency rate	0.029	Consistent

Table 12: Average weights of organizational and government risk criteria.

Criterion	$W^*{}_j{}^{GO}$	Weight
Failure of management lines	$W^*{}_1{}^{GO}$	0.127
The risk of government policies	$W^*{}_3{}^{GO}$	0.1594
Information asymmetry across the green	$W^*{}_1{}^{GO}$	0.2496
Lack of strategic goals in the organization	$W^*{}_4{}^{GO}$	0.3176
Legal risks	$W^*{}_5{}^{GO}$	0.0462
Partnership risks	$W^*{}_6{}^{GO}$	0.1002
Inconsistency rate	0.027	Consistent

5. Discussion

In recent years, due to the pressure caused by customer expectations, market demand, and government guidelines, green supply chain management has become one of

Table 13: Ranking of green supply chain risk criteria.

Criteria	Final weight	Rank
Failure of machinery and equipment	0.04041	9
Design risks	0.006856	23
Lack of skilled workers	0.021851	16
The level of green technology	0.04748	7
Purchase cost risks	0.011937	20
Loss of key suppliers	0.035188	10
Supplier quality issues	0.011729	21
Environmentally friendly raw materials	0.044945	8
Reverse logistics design risks	0.01899	18
Risks of product returns from customers	0.02156	17
Capacity and inventory redesign risk	0.00345	24
Risks of restrictions on financial resources	0.06865	5
Risk related to changes in inflation and currency rates	0.213789	1
Risks of poor financial plans	0.023761	14
The whiplash effect of false information on the amount of demand	084396/0	2
Market dynamics	0.026611	13
Loss of key customers	0.081565	3
Competitive risks	0.018628	19
Failure of management lines	0.027711	12
Risks caused by government policies	0.034781	11
Information asymmetry across the chain	0.054463	6
Lack of strategic goals in the organization	0.0693	4
Legal risks	0.010081	22
Partnership risks	0.021864	15

Table 14: The final ranking of options is based on *R*, S, and Q values.

Company name	Symbol	*S*		*R*		*Q*		Final rank
		Weight	Rank	Weight	Rank	Weight	Rank	
Iran tire	A_1	0.713	5	0.044	5	0.526	5	5
Barez	A_2	0.532	3	0.042	4	0.423	3	3
Kavir tire	A_3	0.621	4	039/0	3	0.432	4	4
Dana	A_4	0.085	1	0.021	1	0	1	1
Artville tire	A_5	0.149	2	0.25	2	0.071	2	2

the important topics for academics as well as industry activists. Nevertheless, there are always risks on the way to effective GSC implementation that make its success difficult.

In the current research, the identification and analysis of green supply chain risks have been considered in order to help industrial owners to identify the most important existing risks and, as a result, increase the efficiency and effectiveness of business. In fact, in the current research, six dimensions, along with 24 subcriteria related to green supply chain risk, were identified and then ranked using the BWM technique.

The results of weighing and ranking the risks of the green supply chain showed that financial risks threaten the tire industry more than other risks in the green supply chain. After financial, organizational, and government risks, demand, operational, supply, and product return risks were placed at the second to sixth places of importance, respectively. Moreover, the results of the criteria ranking indicated that the risk related to changes in the inflation rate and currency is among the most important risks of the GSC from the point of view of experts.

In the studied case, the managers should focus and pay maximum attention to this category of risks and, by adopting policies such as concluding long contracts, and so on, reduce the consequences of inflation and currency changes as much as possible. However, in Mangla et al. [5], different results were obtained, and the risks related to financial resource limitations were identified as the most important risk in the studied company. The difference in the final results of the two mentioned studies can be attributed to the difference in the political and economic situation of the studied countries and the difference in the inflation and currency rates and their fluctuations, which had a significant impact on the position of the studied companies.

On the other hand, the whiplash effect caused by wrong information about the amount of demand was recognized as the second most important risk in GSC. It indicates that from the point of view of experts in the tire industry, a minor error in forecasting the amount of demand can have significant consequences, considering it will cause a whiplash effect on demand and lead to the inefficiency of the entire supply chain. It is suggested to the managers of this industry to adopt some programs such as tightening the reversibility policies and canceling the demands, exchanging information about the market demand with the parts located upstream of the supply chain, and eliminating as many as possible delays. When both are in the flow of goods and the flow of information in the supply chain, sharing information on capacity and inventory with customers and suppliers with the company, and others, will reduce the adverse consequences caused by the whiplash effect of changes in the amount of demand. Moreover, based on the results of the ranking of the studied companies using the FVIKOR technique, Dena Company is in the first place, Artville Tire Company is in the second place, Barez Company is in the third place, Kavir Tire Company is in the fourth place, and finally, Iran Tire Company is in the last place. Finally, in terms of supply chain risks, it is green. In other words, Dena Company is in the best situation in terms of green supply chain risks.

6. Conclusion and Future Research

The main aspect of the current research, which distinguishes it from different previous research works, can be presented in the form of two categories of subject innovation and method innovation. As mentioned before, no research has been conducted on the risk analysis of the green supply chain in the tire industry. However, in the current research, by adopting a relatively comprehensive and comprehensive approach, in addition to identifying different dimensions of risk in the green supply chain, some of the most important risks of the green supply chain in the tire industry were identified and analyzed and therefore had a topical innovation. Moreover, as another contribution, this research used one of the latest multicriteria decision-making techniques, called the hybrid BWM-FVIKOR, in order to determine the weight and rank the risks of the green supply chain.

In this research, various managerial insights have been obtained. At first, by identifying different indicators, it is clear that inflation is a considerable risk for supply chains. Companies should try to invest in the supply chain as soon as possible. In many cases, due to inflation, the power of investment decreases, and as a result, the development of the supply chain is delayed. Moreover, the ranking carried out in the tire industry shows that companies with better environmental performance are always the attention of supply chain managers. In order to develop this research, it is suggested to use gray numbers to show uncertainty in decision-making. Moreover, the data envelopment analysis (DEA) approach is suggested for ranking companies in conditions of uncertainty.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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